PHOTOGRAPHIC CENSUS OF THE STELLER SEA LION HERDS IN ALASKA, 1956-58

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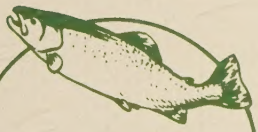

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PHOTOGRAPHIC CENSUS OF THE STELLER SEA LION HERDS IN ALASKA, 1956-58

by

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by

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ABSTRACT

An aerial photographic technique for censusing herds of Steller sea lions *(Eumetopias jubata)* in Alaska is described. The minimum number of sea lions from Cape St. Elias to the Islands of the Four Mountains was estimated to be about 110,000, based on photographic censuses of rookeries and hauling grounds in 1957.

The heaviest population density was recorded in an area between the entrance of Cook Inlet and Unimak Pass. Pronounced seasonal variations were observed, with a peak population on the rookeries from July to September.

A partial aerial photo census of the harbor seals *(Phoca vitulina)* in Alaska is discussed in the appendix.

INTRODUCTION

The problem of predation on salmon is acute in Alaska today because many salmon runs have declined to only a fraction of the level of 20 to 30 years ago. Stringent restrictions placed upon the fishing industry during the last decade to increase escapement have failed to stem this serious decline. Since Steller sea lions *(Eumetopias jubata)* eat salmon as well as halibut and other types of fish, it is only natural that they have been suspected as a contributing cause to the decline of the commercial salmon fisheries. Accusations against sea lions as consumers of food fish have at times been violent but generally without a background of demonstrable facts. Even today, a basis for estimating the possible gain in the monetary value of the salmon runs versus the cost of controlling the number of sea lions does not exist. One of the steps necessary to make such an estimate is to assess the number of animals in different herds. This report describes the development of an aerial photo census technique and results of surveys made during 1956, 1957, and 1958.

Work on a census of sea lions was started in 1952 by W. F. Thompson of the Fisheries Research Institute and consisted of mapping rookeries and hauling grounds in the Shumagin and Kodiak Island areas and experimenting with aerial photographs as a basis for population estimates (Thompson, Thorsteinson, and Bevan, 1955). This work was supported by the

Alaska Salmon Industry, Inc., until 1956 when a contract for more extensive aerial surveys of sea lions was arranged between the Fisheries Research Institute and the U.S. Fish and Wildlife Service. Research under this contract, which provided for several aerial surveys of rookeries at different times of the year, was conducted by Thompson and Ron J. Lopp.

Under another contract between the two agencies, surveys were made in 1957 by Lopp or by Lopp and Mathisen. In 1958, Lopp made three surveys of rookeries in the Shumagin Islands area. He also processed the film each year and made most of the counts of the sea lions on the finished photographs. Mathisen compiled the tables, analyzed the data, and wrote the report.

METHODS OF ENUMERATING MARINE MAMMALS

The classical tagging and recovery methods used in enumerating fish populations are not practical for censusing marine mammals. An exception is the northern fur seal *(Callorhinus ursinus)* on the Pribilof Islands where Kenyon, Scheffer, and Chapman (1954) estimated population size from the ratio of tagged-to-untagged fur seals on the rookeries. Most of the fur seals there are confined to a few rookeries where they can be observed easily and where many thousands are harvested each year. Since sea lions are scattered on hundreds of islands and are not harvested, their number cannot now be estimated by the tagging and recovery method.

Usually, visual counts are used for estimating populations of seals and sea lions. In California visual counts of sea lion rookeries within the boundaries of the State have been conducted systematically for a number of years. The first survey dates back to 1927 (Bonnot, 1928). An account of the procedure used follows:

> The method used for taking the census in this report was to approach the rookery under cover if possible, or if this could not be done, to approach the animals very slowly. When within a reasonable distance, a count or estimate was made and a picture, or pictures, taken. A closer position was then gained and the same procedure repeated. It was found that when counts were made the photographs bore them out, but when estimates were made, the photographs proved them to be high in nearly all cases. (p. 27).

Because there are few rookeries in California and only three with more than 400 animals, results from the procedure described by Bonnot were adequate. Similar surveys followed (Bonnot, 1928, 1931, 1937; Bonnot, Clark, and Hatton, 1938). In 1946 Bonnot and Ripley (1948) used airplanes and Navy blimps to obtain suitable photographs of rookeries. The photographs were used primarily to check ground survey counts made by two or three independent surveyors. One apparent drawback to the aerial census was the difficulty in distinguishing between the Steller and the California sea lions *(Zalophus californianus)*. This problem does not exist in Alaska where the Steller sea lion is the only species. The northern limit of the range of the California sea lion is at Barkley Sound in British Columbia (Scheffer, 1958).

AERIAL PHOTOGRAPHIC CENSUS IN ALASKA, 1956-58

The districts surveyed aerially from 1956 to 1958 extend from Cape St. Elias (144° W.) to the Islands of the Four Mountains (170° W.), or about 1,100 miles in a straight line (fig. 1). The actual flight line needed to cover all coastal rookeries between these two limits is considerably longer.

Equipment and Techniques

Among different planes used during the investigations, a twin-engined amphibian most adequately provided efficient cruising speed, cruising range, and power to overcome treacherous downdrafts at the rookeries.

While photographs were being taken, the speed of the plane was about 100 to 120 miles per hour, and the pilot maintained the plane at a distance of 300 to 400 feet from the animals. Generally all photographs were exposed during the first circuit of the rookery, but at rookeries with highly indented shorelines, sometimes a second or third coverage was needed.

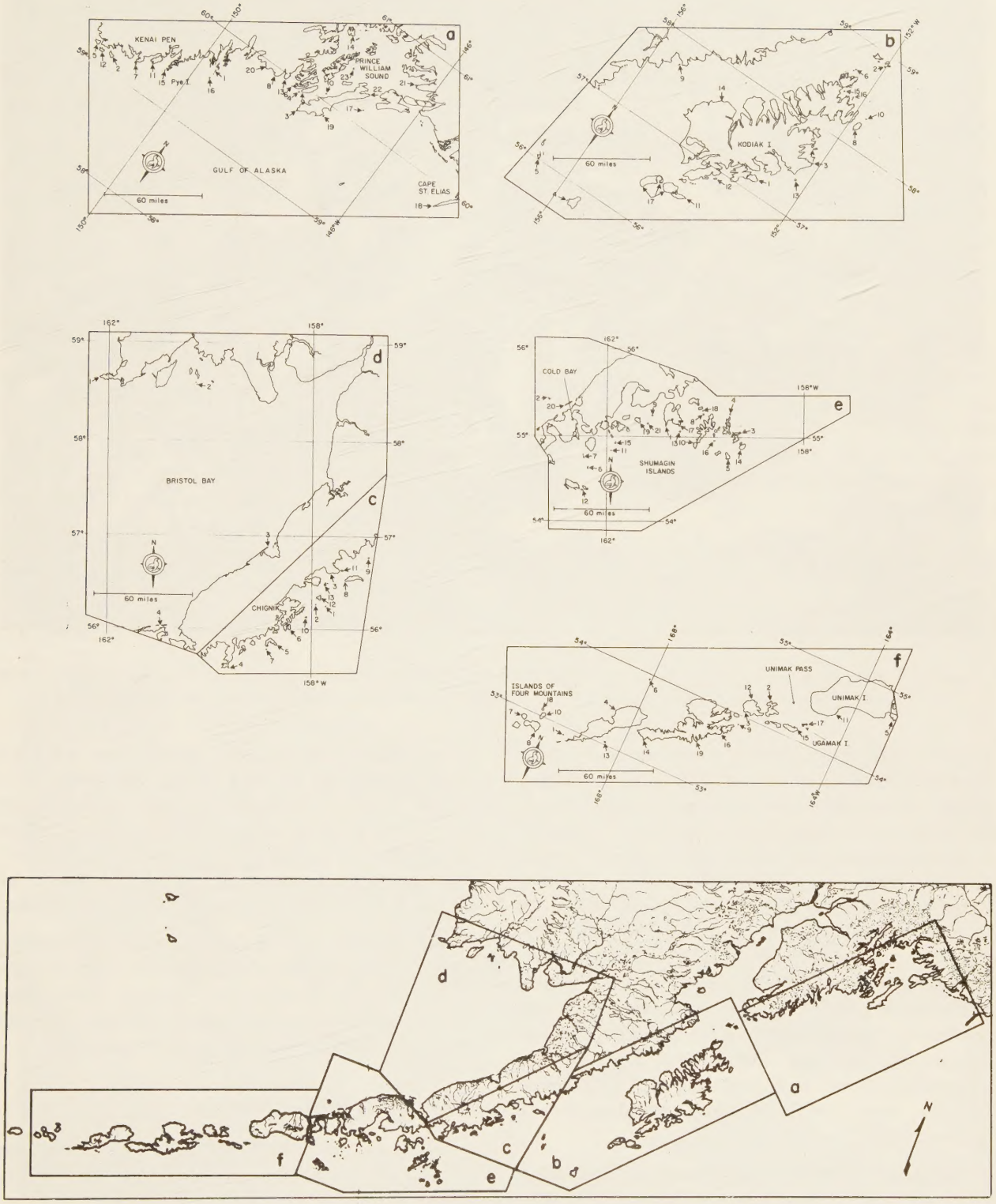

Figure 1.--Sea lion rookeries where aerial surveys were made from 1956 to 1958. Rookeries numbered by districts as outlined on map: 1A - Prince William Sound-Kenai; 1B - Kodiak Island; 1C - Chignik; 1D - Bristol Bay; 1E - Shumagin Island-Cold Bay; 1F - Eastern Aleutian Islands.

Figure 2.--Part of sea lion rocks adjacent to Pye Island in the Prince William Sound district. The counted portion is outlined, and the overlap is determined in conjunction with the adjacent frame seen in figure 3.

A 35-mm. camera with interchangeable lens and automatic film advance was used during most of the surveys discussed in this paper. It combined compactness and ease of rapid-sequence exposure and was far more satisfactory than an aerial camera (k-20) that was used occasionally. Usually all pictures were exposed through an open window in the plane's cockpit. A 90-mm. lens was most satisfactory, but it was occasionally replaced with a 50-mm. or a 135-mm. lens to meet changing flying conditions. Today several other types of cameras that offer a choice of negative sizes and high-speed, long focus lenses are available for rapid-sequence photography.

Exposure time was usually 1/1000 of a second and seldom more than 1/500 of a second. Slower exposures invariably resulted in blurred pictures that were difficult or almost impossible to count with any degree of precision.

Ordinarily, black and white film with an ASA rating of 80 was used, but under adverse light conditions it was replaced by film with an ASA rating of 200. Films were developed in Kodak D-76 or with Ethol ultra-fine grain developer, and glossy prints, 8 by 10 inches, were prepared of the negatives.

An attempt was made to expose negatives with a 25-percent overlap wherever there was a continuous distribution of sea lions. Enlargements could then easily be matched and the best portion of each print counted.

Categories of Animals

Four categories of animals were recorded: (1) adults on rocks, (2) adults in the water, (3) estimated animals, and (4) pups.

The first two categories represented all sea lions that clearly could be counted from the photographs on land or in the water. A

high percentage of sea lions in the water generally indicated that the rookery had been disturbed. Because sea lions were difficult to detect in the water, many escaped notice, and the resulting counts were probably minimal. In 1956 the percentage of sea lions counted in the water was 4.4, whereas in 1957 and 1958 the percentages fell to 0.5 and 1.3. This undoubtedly reflects more skill by the photographer combined with a more thorough knowledge of the rookeries.

At times some photographs were blurred, preventing an accurate count. Also, groups of animals in shaded areas or extremely far from the photographer made counting difficult and somewhat uncertain. Counts falling within these categories were therefore separated into one group labelled "estimated animals" to indicate a variable accuracy of the given figure. Such estimates were 5.7 percent of the final census figure in 1956, 2.6 percent in 1957, and 2.4 percent in 1958. With few exceptions, this percentage was similar among the different types of rookeries and hauling grounds.

Accuracy of the pup counts is also variable. The dark color of newborn pups makes it difficult to detect them on black and white prints. During summer and fall, however, when their color lightens and they become larger, they are easier to see on photographs.

Analysis of Photographs

To aid in counting and to prevent duplicate counts, each animal was marked on the photograph with an ink dot. An example of the procedure is given in figures 2 and 3 where the animals on a rookery on Pye Islands (rookery 15, fig. 1A) have been marked on overlapping photographs. Accuracy depends

Figure 3.--Part of sea lion rocks adjacent to Pye Island in the Prince William Sound district. This print is used to determine the amount of overlap with the previous print (fig. 2). The total count is made from the two photographs.

on the ability of the counter to distinguish a sea lion from its surroundings. This requires field experience with the animals that enables the counter to visualize the size of an animal in relation to the distance and angle from the axis of the lens. Some sea lions will not be detected at all because they may be partly or wholly obscured by rocks or other animals. Therefore, counts of the animals in the photographs will always be minimal. The greatest deviation from the actual population may be expected in heavily populated rookeries on rough terrain.

Consistency in interpretation is perhaps the most important factor in analyzing photographs. This has been tested by comparing the counts of three different persons who made independent readings from duplicate series of photographs on Chernabura Island.[1] Ron Lopp, an experienced counter, was designated as counter A and read a series of photographs twice, using unmarked pictures in every case. His deviations generally amounted to only a few animals between first and second readings, regardless of whether the photograph included fewer than 10 or even when there were as many as 250 animals (fig. 4).

Counter B was an experienced aerial stream surveyor with long training in estimating salmon escapements. At his first attempt to count sea lions on photographs, counter B deviated from counter A, the experienced counter, particularly on photographs with large numbers of animals. On these, his estimates were lower than those of the experienced counter.

Counter C was a clerical assistant without any previous experience. Her deviations from counter A were considerably larger than those between counter A and counter B and generally showed a positive bias.

Lopp made all final readings on our experiments with the exception of Prince William Sound-Kenai district on the September survey

[1] Baade, Robert T., Ole A. Mathisen, and Ron J. Lopp. Studies on the Steller sea lion *(Eumetopias jubata)* on Chernabura Island in the Shumagin area of Alaska during the summer of 1958. Typed manuscript, on file, Fisheries Research Institute.

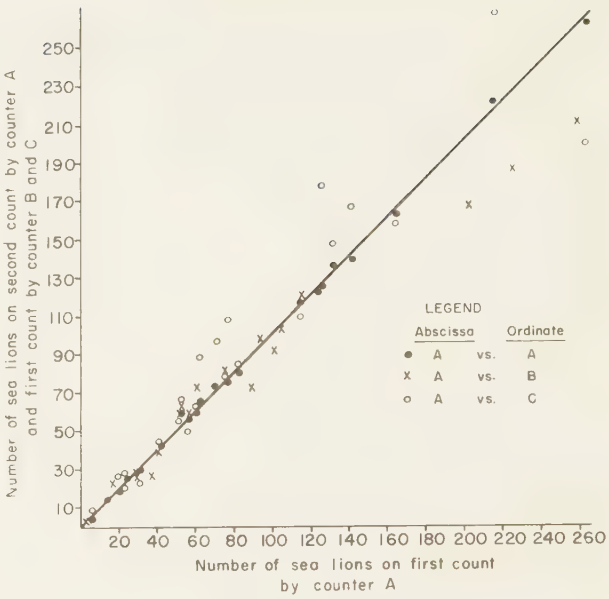

Figure 4.--Comparison of results of three counters interpreting independently the same series of photographs of Chernabura Island sea lion rookery.

and all districts on the December survey in 1957. These were read by Donald E. Rogers.

Summary of Counts

Summarized in tables 1 to 6 are counts obtained during the years 1956-58. Each year the surveys were numbered consecutively. Three surveys were made in 1956, seven in 1957, and three in 1958. The surveyed region was divided into six districts whose boundaries are outlined on the map in figure 1. These districts are artificial units created for ease of description and do not reflect groups or races of sea lions. Within each district each rookery or hauling ground has been given a number, which is listed in tables 1 to 6 and which corresponds to a number on the maps in figure 1. Rookeries shown on figure 1 that are not included in the tables had harbor seals *(Phoca vitulina)* only. The counts of harbor seals are given in appendix table 1.

Counts of adults and pups are separated. Counts of adults in the water and estimated animals have been added to the counts of adults on the rocks for the total figure of adult animals. All photographs and detailed basic counts are available for inspection in the library of the Fisheries Research Institute.

Table 1.--Numbers of sea lions, Prince William Sound-Kenai district, 1956-57, determined from photos

[* indicates visual estimate; ** pups included in adult counts]

	Rookery and code number 1/	Adults	Pups	Total	Adults	Pups	Total	Adults	Pups	Total	Adults	Pups	Total
	1956:												
		Survey 1, July 21-22			*Survey 2, Sept. 1-2*			*Survey 3, Dec. 14*					
1.	Chiswell Island	1,459	564	2,023	1,578	351	1,929	4,220	539	4,759			
2.	Chugach Island	8	0	8*	6	0	6*						
3.	Cape Cleare	1	0	1*									
4.	Danger Island	249	49	298	225	0	225*						
5.	Elizabeth Island	108	21	129	6	0	6*	0	0	0*			
6.	Point Elrington	25	6	31	0	0	0*	550	0	550*			
7.	Gore Point	195	26	221				0	0	0*			
8.	Cape Junken	12	0	12*	0	0	0*						
9.	Latouche							0	0	0*			
10.	Needles	179	16	195	150	0	150*	165	0	165			
11.	Nuka Point	0	0	0									
12.	Pearl Island	687	50	737	0	0	0*						
13.	Puget Cape	20	0	20	0	0	0	0	0	0*			
15.	Pye Islands	1,415	368	1,783	1,707	340	2,047	1,431	35	1,466			
16.	Seal Rocks (Kenai)	450	49	499									
17.	Seal Rocks (Prince William Sound)	162	21	183									
19.	Wooded Island	466	213	679	2,486	70	2,556	1,357	337	1,694			
	Total	5,436	1,383	6,819	6,158	761	6,919	7,723	911	8,634			
	1957:												
		Survey 1, Mar. 24			*Survey 2, May 29*			*Survey 3, June 27*			*Survey 7, Oct. 2*		
1.	Chiswell Islands	4,715	0	4,715	3,591	2	3,593	1,930	82	2,012	2,424	103	2,527
2.	Chugach Island	0	0	0*	20	0	20*				0	0	0*
4.	Danger Island	75	0	75*	100	0	100*	0	0	0*			
5.	Elizabeth Island	0	0	0*									
6.	Point Elrington	200	0	200*	300	0	300*	250	0	250*	330	23	353
7.	Gore Point	0	0	0*	31	0	31	200	0	200*	35	0	35*
8.	Cape Junken	0	0	0*				0	0	0*	0	0	0*
9.	Latouche										77	9	86
10.	Needles	190	0	190				179	0	179	130	0	130
11.	Nuka Point	0	0	0*	160	0	160	0	0	0*	0	0	0*
12.	Pearl Island	12	0	12*									
13.	Puget Cape	0	0	0*				0	0	0*	0	0	0*
14.	Perry Island	80	0	80*									
15.	Pye Island	1,050	0	1,050	6,073	0	6,073	2,848	141	2,989	1,869	322	2,191
16.	Seal Rocks (Kenai)	100	0	100*				250	0	250*	60	0	60*
17.	Seal Rocks (Prince William Sound)	0	0	0*							95	0	95
18.	Cape St. Elias										1,253	90	1,343
19.	Wooded Island	810	0	810				3,000**		3,000*	3,668	94	3,762
	Total	7,232	0	7,232	10,275	2	10,277	8,657	223	8,880	9,941	641	10,582

1/ Code numbers refer to map in figure 1A.

Surveys were made with different degrees of completeness. At times a rookery was not included in a survey because weather conditions prevented flying in the area of that rookery. At other times only the major rookeries were visited. The most complete coverage was in 1957 on survey 7 when all rookeries and almost all known hauling areas between Cape St. Elias and the Islands of the Four Mountains, which form the eastern and western boundaries of the areas surveyed, were covered.

Tables 1 to 6 probably include the most important sea lion rookeries and hauling areas, but undoubtedly other localities could be added to the list, such as areas where no breeding takes place and sea lions only haul out. These areas change as sea lions move in search of food or are disturbed.

VARIATIONS IN COUNTS

The sea lion census technique developed in our studies will give the number of animals on a rookery at the time of a survey quite accurately, but the fraction of the total population that photographed animals represent will not be known because of sea lions that may be absent from the rookery, for example, when feeding.

Table 2.--Numbers of sea lions, Kodiak Island district, 1956-58, determined from photos

[* indicates visual estimate; ** pups included in adult counts]

	Rookery and code number 1/	Adults	Pups	Total	Adults	Pups	Total	Adults	Pups	Total
		1956:								
		Survey 1, July 22-25			*Survey 2, Sept. 1-2*			*Survey 3, Dec. 10-14*		
1.	Cape Barnabas	628	5	633	2,467	20	2,487	535	95	630
2.	Barren Islands:									
	a. W. Amatuli Island	25	0	25*	25	0	25*			
	b. Sugarloaf Island	7,698	4,300	11,998	6,432	4,632	11,064	400	0	400*
	c. Ushagat Island	198	0	198	120	0	120*			
3.	Cape Chiniak	214	0	214	50	0	50*	110	20	130*
5.	Chowiet Island	0	0	0*						
6.	Latax Rocks	94	0	94						
8.	Marmot Island	2,262	926	3,188	3,817	1,781	5,598	1,445**		1,445
9.	Puale Bay	2,831	535	3,366						
11.	Cape Sitkinak	270	0	270*	161	29	190	2	0	2*
12.	Twoheaded Island	2,897	131	3,028	3,911	350	4,261	1,903	260	2,163
13.	Ugak Island	442	0	442	50	0	50*	0	0	0*
14.	Uyak Cape	5	0	5*						
	Total	17,564	5,897	23,461	17,033	6,812	23,845	4,395	375	4,770
		1957:								
		Survey 1, Mar. 21			*Survey 2, May 27-29*			*Survey 3, June 27-28*		
1.	Cape Barnabas	540	0	540	1,561	0	1,561	1,598	0	1,598
2.	Barren Islands:									
	a. W. Amatuli Island							1,576	0	1,576
	b. Sugarloaf Island	585	0	585	7,916	0	7,916	11,113	850	11,963
	c. Ushagat Island							789	45	834
3.	Cape Chiniak	645	0	645				772	0	772
4.	Chirikof Island				2,186	1	2,187	1,695	47	1,742
5.	Chowiet Island				1,803	17	1,820	6,014	309	6,323
6.	Latax Rocks							3,334	0	3,334
7.	Long Island							75	0	75*
8.	Marmot Island	1,425	0	1,425	5,077	15	5,092	3,866	291	4,157
9.	Puale Bay				2,918	0	2,918			
10.	Sea Lion Rock (Marmot Island)				1,609	0	1,609	300	0	300*
11.	Cape Sitkinak	470	0	470				343	0	343
12.	Twoheaded Island	2,740	0	2,740				2,738	72	2,810
13.	Ugak Island	0	0	0				318	0	318
	Total	6,405	0	6,405	23,070	33	23,108	34,531	1,614	36,145
		1957--Con.						1958:		
		Survey 7, Sept. 29			*Survey 8, Dec. 4-5*			*Survey 1, May 20*		
1.	Cape Barnabas	900	0	900*	135	0	135	880**		880
2.	Barren Islands:									
	b. Sugarloaf Island	3,218	532	3,750	955	0	955			
3.	Cape Chiniak	265	0	265	457	0	457			
4.	Chirikof Island	2,355	95	2,450	1,071	0	1,071			
5.	Chowiet Island	4,911	839	5,750	987	0	987	1,642	0	1,642
8.	Marmot Island	5,247	1,543	6,790	2,872	0	2,872			
9.	Puale Bay	600	0	600*						
10.	Sea Lion Rock (Marmot Island)	78	0	78	255	0	255			
11.	Cape Sitkinak	202	4	206	69**		69			
12.	Twoheaded Island	3,652	205	3,857	1,445**		1,445	4,178	8	4,186
13.	Ugak Island	122	0	122	108	0	108	1,019	0	1,019
	Total	21,550	3,218	24,768	8,354	0	8,354	7,719	8	7,727

1/ Code numbers refer to map in figure 1B.

Table 3.--Numbers of sea lions, Chignik district, 1956-57 determined from photos

[* indicates visual estimate]

	Rookery and code number 1/	Adults	Pups	Total	Adults	Pups	Total
		1956:			1957:		
		Survey 1, July 26-Aug. 4			*Survey 2, May 27-28*		
1.	Atkulik Island	12	0	12*	6	0	6*
2.	Kak Island	97	0	97	0	0	0*
3.	Cape Kumlik	1	0	1	0	0	0*
4.	Kupreanof Point	0	0	0*			
5.	Mitrofania Island	216	0	216	0	0	0*
6.	Seal Cape	11	0	11*	0	0	0*
7.	Spitz Island	40	0	40*	731	0	731
8.	Sutwik Island	733	5	738	0	0	0*
9.	Ugaiushak Island	572	71	643	213	0	213
	Total	1,682	76	1,758	950	0	950
		1957--Con.					
		Survey 3, June 28			*Survey 7, Oct. 1-2*		
2.	Kak Island	150	0	150*	47	0	47*
4.	Kupreanof Point				35	0	35*
5.	Mitrofania Island				80	0	80*
7.	Spitz Island	125	0	125*	0	0	0*
8.	Sutwik Island	0	0	0*	300	0	300*
9.	Ugaiushak Island				120	0	120*
	Total	275	0	275	582	0	582

1/ Code numbers refer to map in figure 1C.

Diurnal Variations

Bonnot (1928) stated that sea lions do most of their feeding at night or early in the morning, and he recommended that any census counts be made between 1000 in the morning and 1500 or 1600 in the afternoon.

Bonnot's recommendation was substantiated by the Institute's studies on Chernabura Island in 1958.[2] In one undisturbed control area, designated as area I, visual censuses were taken during established hours each day (table 7). On Saturdays and Sundays the counts were not made at any definite time. Although counts of pups remained stable at all hours, counts of adults on the rocks were high from early morning until afternoon. Toward evening and after sunset when the sea lions were feeding, counts were smaller.

This diurnal cycle was modified by the surf. If a plot is made of the height of ocean swell and the average number of animals counted during the season, an inverse relation appears (fig. 5). Apparently on stormy days, sea lions on Chernabura Island preferred to go to sea and ride out heavy waves in the water.

No systematic studies of these behavior patterns were made because good aerial pictures depend on moderate wind and calm sea,

[2] See footnote 1 on p. 6.

Table 4.--Numbers of sea lions, Bristol Bay district, 1956-57 determined from photos

[* indicates visual estimate]

	Rookery and code numbers 1/	Adults	Pups	Total	Adults	Pups	Total
		1956: *Survey 1, July 26-Aug. 4*			1957: *Survey 6, Sept. 10*		
1.	Cape Newenham.....	250	0	250*	30	0	30*
2.	Twin Island.....	300	0	300*	147	0	147
	Total.....	550	0	550	177	0	177

1/ Code numbers refer to map in figure 1D.

and exposure of photographs between the hours of 1000 and 1600. The counts, therefore, reflect a period when both the behavior pattern of sea lions and the effect of weather conditions tended to stabilize and maximize the counts.

Nevertheless, the results of surveys made on closely spaced trips or on successive days differed substantially. The differences appear to be erratic and may be caused by sea lions moving from land to sea or from one island to another. In addition, certain age groups, such as immature males, may not frequent the rookeries at all during the breeding season. This appeared to be the case on Chernabura Island in 1958.[3] The length frequency distribution of males shows no immature males after the yearling stage.

Seasonal Variations

From a cursory inspection of tables 1 to 6, it is evident, either from the counts obtained on individual rookeries or from the total count of a district, that great changes took place in the number of sea lions on a rookery during the year. Generally the counts were low in the early spring, reached a maximum in the late summer months, and declined again toward the end of the year.

To estimate seasonal changes, counts from successive surveys of 18 major rookeries were summarized for 1956 and 1957 (table 8). On survey 2 in 1957 some of the large rookeries were not covered, and estimated figures were used. These were derived from the arithmetic mean of the counts made on surveys 1 and 3 in the same year or the nearest adjacent surveys.

Two of the three districts, which extend from Cape St. Elias to False Pass (fig. 1a, 1b, and 1e), show the same general fluctuations, with a build-up in population density during the breeding season in June. The summer populations were commonly from two to three times larger than the winter ones (fig. 6).

Two explanations appear possible: many of the animals may migrate from the area, or while foraging in the sea they may spend increasing amounts of time away from the rookeries.

Since no winter survey was made of rookeries west of Unimak Pass, it is not known if there is a migration in that direction. It seems unlikely, because the winter weather is more severe to the west. Probably the observed decline during winter is simply the result of more intensive feeding and longer journeys from the rookeries and hauling areas.

[3] See footnote 1 on p. 6.

Table 5.--Numbers of sea lions, Shumagin Islands-Cold Bay district, 1956-58 determined from photos

[* indicates visual estimate; ** pups included in adult counts]

	Rookery and code number 1/	Adults	Pups	Total	Adults	Pups	Total	Adults	Pups	Total
	1956:									
		Survey 1, July 28-Aug. 9			*Survey 2, May 28-29*			*Survey 3, June 28-30*		
1.	Acheridin Point	212	0	212	500	0	500*	399	0	399
2.	Amak Island:									
	a. Sea Lion Rock	3,780	1,035	4,815	2,855	11	2,866	2,871	229	3,100
	b. Amak Island	252	1	253				3,016	0	3,016
3.	Atkins Island	2,861	215	3,076	2,398	25	2,423	4,995	185	5,180
4.	Castle Rock	419	0	419	600**		600*	600**		600*
5.	Chernabura Island	1,825	53	1,878				4,806	76	4,882
6.	Cherni Rock				0	0	0*	386	0	386
7.	Clubbing Rocks	3,292	2,321	5,613	1,053	0	1,053	1,556	515	2,071
8.	Haystacks							100	0	100*
9.	Jude Island	2,070	999	3,069				5,042	612	5,654
10.	Nagai Island	15	0	15				200**		200*
11.	Pinnacle Rocks	798	185	983						
12.	Sanak Island:									
	a. Lookout Point	342	117	459						
	b. Seal Rock	3,265	8	3,273						
13.	Sea Lion Rocks (Unga Island)	396	4	400	336	0	336	372	0	372
14.	Simeonof Island	135	5	140	0	0	0*			
15.	Sushilnoi Rocks							10	0	10*
16.	Twin Islands	2	0	2	0	0	0*			
17.	Unga Cape	29	0	29				10	0	10*
18.	Whaleback Rock	606	0	606	50	0	50*	1,041	4	1,045
19.	Wosnesenski Island							318	0	318
	Total	20,299	4,943	25,242	7,792	36	7,828	25,722	1,621	27,343
		Survey 4, Aug. 6-14			*Survey 7, Aug. 28-Oct. 2*			*Survey 8, Dec. 4*		
1.	Acheridin Point	229	0	229	37	0	37			
2.	Amak Island:									
	a. Sea Lion Rock	2,887	169	3,056	4,694	424	5,118	2,775**		2,775
	b. Amak Island	569	1	570	570	113	683	1,401**		1,401
3.	Atkins Island	3,769	482	4,251	4,718	725	5,443	2,171	0	2,171
4.	Castle Rock	1,379	260	1,639	2,028	67	2,095	1,538**		1,538
5.	Chernabura Island	3,457	323	3,780	4,427	550	4,977	1,964**		1,964
6.	Cherni Rock				0	0	0*			
7.	Clubbing Rocks	4,919	2,054	6,973	1,875	184	2,059	1,039	0	1,039
9.	Jude Island	1,892	570	2,462	1,131	282	1,413	259**		259
10.	Nagai Island	85**		85*	630	49	679	150**		150*
11.	Pinnacle Rocks	0	0	0	3,142	641	3,783	1,163	0	1,163
12.	Sanak Island:									
	a. Lookout Point	0	0	0*	0	0	0*			
	b. Seal Rock	0	0	0*	0	0	0*			
13.	Sea Lion Rocks (Unga Island)	382	0	382	213	0	213			
14.	Simeonof Island	25	0	25*						
15.	Sushilnoi Rocks	0	0	0						
17.	Unga Cape	0	0	0						
18.	Whaleback Rock	977	0	977	131	0	131			
19.	Wosnesenski Island	35	0	35*		0				
	Total	20,605	3,859	24,464	23,596	3,035	26,631	12,460	0	12,460
	1958:									
		Survey 1, May 20			*Survey 2, July 3*			*Survey 3, Aug. 2*		
1.	Acheridin Point	33	0	33	270	0	270	43	0	43
3.	Atkins Island	2,993	1	2,994	3,377	895	4,272	4,443	1,168	5,611
4.	Castle Rock	3,327	0	3,327	1,021	23	1,044	913	29	942
5.	Chernabura Island	2,623	0	2,623	1,980	364	2,344	164	144	308
9.	Jude Island	314	0	314	2,019	455	2,474	1,727	322	2,049
13.	Sea Lion Rocks (Unga Island)	488	0	448	201	3	204	262	0	262
14.	Simeonof Island				0	0	0*	0	0	0*
19.	Whaleback Rock	609	0	609	422	0	422	664	0	664
	Total	10,347	1	10,348	9,290	1,740	11,030	8,216	1,663	9,879

1/ Code numbers refer to map in figure 1E.

Table 6.--Numbers of sea lions, Eastern Aleutian Islands district, 1956-57, determined from photos

[* indicates visual estimate; ** pups included in adult counts]

	Rookery and code number 1/	1956: Survey 1, Aug. 2-9			1957: Survey 5, Aug. 13-14			Survey 7, Sept. 30–Oct. 1		
		Adults	Pups	Total	Adults	Pups	Total	Adults	Pups	Total
1.	Adugak Island							1,275	96	1,371
2.	Akun Island				1,361	0	1,361			
3.	Akutan Island				7,675	994	8,669	9,275	1,735	11,010
4.	Cape Aslik							169	0	169
5.	Bird Island	262	0	262				61	0	61
6.	Bogoslof Island				3,707	3,106	6,813	2,136	1,217	3,353
7.	Carlisle Island							45	0	45*
8.	Concord Point							212	0	212
9.	Egg Island				0	0	0*	327	2	329
10.	Kagamil Island							38	0	38
11.	Cape Lutke	23	0	23*						
12.	North Head							719**		719
13.	Ogchul Island							2,966	425	3,391
14.	Serpent Point							45	0	45*
15.	Tigalda Island							103	0	103
16.	Udagak Strait							45	0	45*
17.	Ugamak Island							14,536	1,466	16,002
18.	Uliaga Island							239	0	239
19.	Whalebone Cape							498**		498
	Total	285	0	285	12,743	4,100	16,843	32,698	4,941	37,630

1/ Code numbers refer to map in figure 1F.

Table 7.--Average numbers of sea lions observed in area I Chernabura Island, summer 1958 1/

Day of week	Time	Average number observed	
		Adults on rocks	Pups
Monday	0400-0800	320	76
Tuesday	0800-1200	292	69
Wednesday	1200-1600	314	74
Thursday	1600-2000	302	69
Friday	2000-2400	231	71

1/ Data from Baade, Mathisen, and Lopp; see text footnote 1, on p. 6.

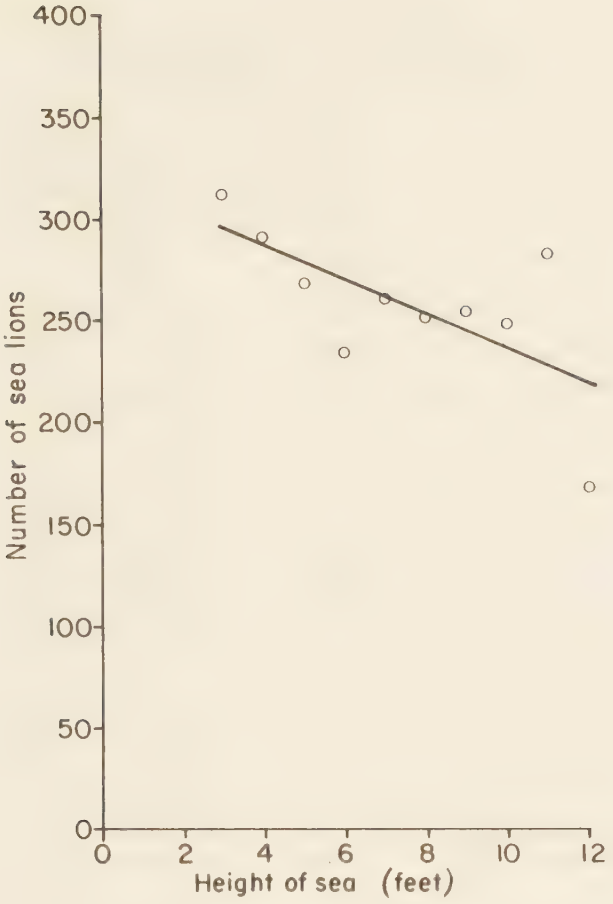

Figure 5.--Sea lion population-height of ocean swell relation, Chernabura Island, 1958.

The variation in the counts, i.e., seasonal and diurnal changes, and the difficulty in identifying all of the animals in the photos, indicate that the counts are minimal estimates of the total population.

Total Population Estimate

A minimum estimate of the total population can be obtained by summing the results shown in tables 1 to 6 of the most complete surveys made when the sea lion populations on land were high (table 9).

The three districts, Prince William Sound-Kenai, Kodiak Island, and Shumagin-Cold Bay, were all surveyed during late June 1957, excluding the possibility of any duplication in counts because of migration between rookeries there. The Eastern Aleutian Islands survey took place about 3 months later at a time when the total counts of the Kodiak and Shumagin Islands areas were slightly below the June peak but not enough below to indicate any significant migration. The two minor districts, Chignik and Bristol Bay, were surveyed in spring and fall respectively.

No aerial survey was made of the sea lion herds of the Aleutian Islands west of longitude 170 W. However, visual counts and estimates were made of a few rookeries and hauling areas by crews of tagging vessels from the Fisheries Research Institute that were operating in the North Pacific Ocean and the Bering Sea (table 10). These counts, which total 4,595, include only a fraction of the islands inhabited by sea lions, and the total population is certainly much larger.

The scientific leaders of the tagging vessels estimated the total number of sea lions in the Western Aleutian Islands at 40,000. In May 1959, Kenyon and Rice (1961) surveyed the same area and estimated 44,630 animals. They made a survey of the Eastern Aleutian Islands in March 1960 and estimated 55,115 sea lions, whereas we estimated 45,917 animals in the Eastern Aleutian Islands area, using corresponding estimates from tables 5 and 6. Although the individual rookery counts at times differed substantially, the total estimates made by Kenyon and Rice for the Eastern and Western Aleutian Islands are similar to the estimates made by Fisheries Research Institute personnel. However, with our present insufficient knowledge of seasonal variations within one rookery and between rookeries, as well as between years, any further discussion and comparison of the figures from individual rookeries would need additional observations.

No photo census exists for rookeries in Southeastern Alaska, but visual estimates were made by Maurice Fields of the Fish and Wildlife Service in the spring of 1957 while he was flying patrol of the halibut fishery with the U.S. Coast Guard (table 11). These estimates, totaling 8,715 animals, correspond to earlier ones given by Brooks (Alaska Fisheries Board and Alaska Department of Fisheries, 1957, p. 52-54).

Table 8.--Seasonal counts of selected major sea lion rookeries, 1956 and 1957

[* indicates visual estimate; ** estimate based on average of counts from surveys on adjacent rookeries]

District, rookery, and code number[1/]	1956[2/]			1957					
	Survey 1 July-Aug.	Survey 2 Sept.	Survey 3 Dec.	Survey 1 Mar.	Survey 2 May	Survey 3 June	Survey 4 Aug.	Survey 7 Sept.-Oct.	Survey 8 Dec.
Prince William Sound-Kenai:									
1. Chiswell.....	2,023	1,929	4,759	4,715	3,593	2,012		2,527	
6. Point Elrington.....	31	0	550*	200*	300*	250*		353	
10. Needles.....	195	150*	165	190	185**	179		130	
15. Pye Islands.....	1,783	2,047	1,466	1,050	6,073	2,989		2,191	
19. Wooded Island.....	679	2,556	1,694	810	1,900**	3,000*		3,762	
Total.....	4,711	6,682	8,634	6,965	12,051	8,430		8,963	
Kodiak Island:									
1. Cape Barnabus.....	633	2,437	630	540	1,561	1,598		900*	135
2. Sugarloaf.....	11,998	11,064	400*	585	7,916	11,963		3,750	955
3. Cape Chiniak.....	214	50*	130*	645	708**	772		265	457
8. Marmot Island.....	3,188	5,598	1,445	1,425	5,092	4,157		6,790	2,872
11. Cape Sitkinak.....	270*	190	2*	470	406**	343		206	69
12. Twoheaded Island....	3,028	4,261	2,163	2,740	2,775**	2,810		3,857	1,445
13. Ugak Island.....	442	50*	0*	0	159**	318		122	108
Total.....	19,773	23,700	4,770	6,405	18,617	21,961		15,890	6,041
Shumagin Islands-Cold Bay:									
2. Amak Island (Sea Lion Rock)....	5,068				2,866	6,116	3,626	5,801	4,176
3. Atkins Island.....	3,076				2,423	5,180	4,251	5,443	2,171
4. Castle Rock.....	419				600*	600*	1,639	2,095	1,538
5. Chernabura Island...	1,878				3,380**	4,882	3,780	4,977	1,964
7. Clubbing Rocks.....	5,613				1,053	2,071	6,973	2,059	1,039
9. Jude Island.....	3,069				4,360**	5,654	2,462	1,413	259
Total.....	19,123				14,682	24,503	22,731	21,788	11,147

1/ Code numbers from figure 1.
2/ For exact dates of surveys, see tables 1, 2, and 5.

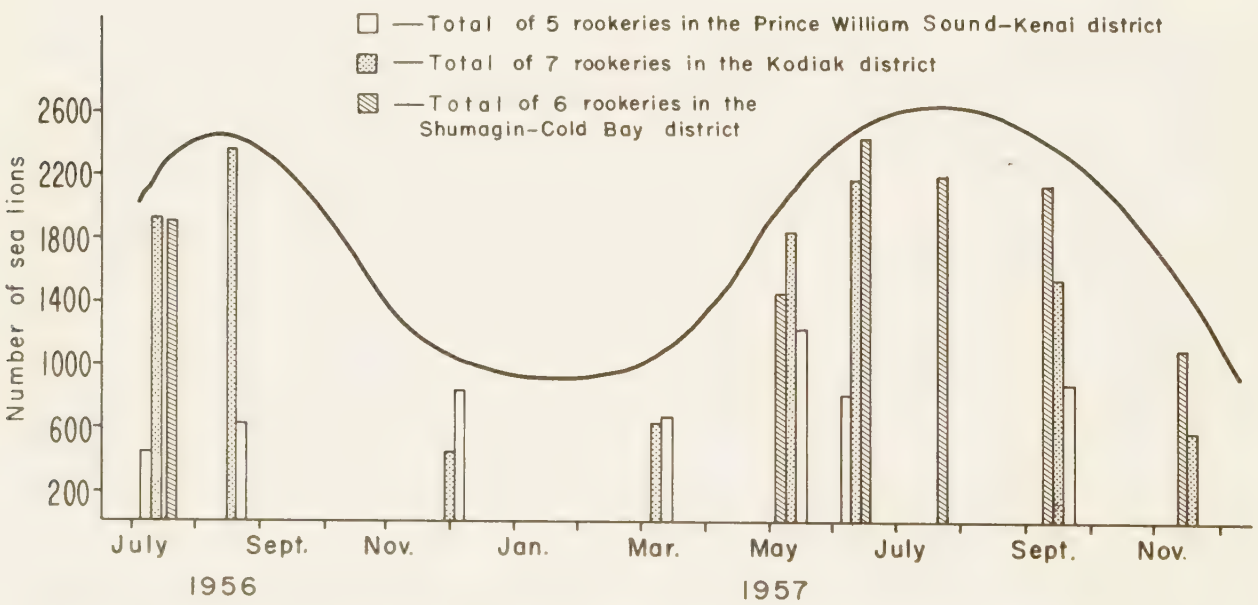

Figure 6.--Size of sea lion populations on selected major rookeries and hauling areas, 1956 and 1957.

Table 9.--Summary of aerial surveys made in six districts when sea lion populations on land were high, 1957

District	Date	Survey number	Number of animals		
			Actual count	Visual estimate	Total[1]
Prince William Sound-Kenai	June 27	3	5,180	3,700	8,880
Kodiak Island	June 27-28	3	35,770	375	36,145
Chignik	May 27-28	2	944	6	950
Bristol Bay	Sept. 10	6	147	30	177
Shumagin-Cold Bay	June 28-30	3	27,133	210	27,343
Eastern Aleutian Islands	Sept. 30-Oct. 1	7	37,495	135	37,630
Total			106,669	4,456	111,125

1 The total numbers of animals are given in tables 1 to 6. For the sake of completeness the numbers of estimated animals have been given. Fogging of one roll of film taken in the Prince William Sound-Kenai district made it necessary to use estimated figures for some rookeries, including Wooded Island.

Table 10.--Sea lion counts on western Aleutian Islands, May to September, 1956-58

Island and rookery	Year	Visual estimate from tagging boats
1. Adak Island (group)		
West side Cape Yakak	1956	350
2. Agattu Island		
Karab Cove	1957	30
Gillon Point	1958	1,000
3. Amchitka Island		
Silo Point	1956	200
Half mile east Silo Point	1956	50
East Cape (rock offshore)	1956	300
East Cape (north side)	1956	300
Ivakin Point	1956	200
4. Amlia Island		
Sagigik Island	1956	50
West entrance Sveichnikof Harbor	1957	50
5. Attu Island		
Chirikof Point	1957-58	125
Cresta Point		75
6. Buldir Island		
North side	1957	550
7. Kiska Island		
Sabaka Rock	1957	150
Sea Lion Rock	1958	100
Rat Island	1958	200
8. Semisopochnoi Island		
South side (2 areas)	1957	775
East end	1958	75
9. Ulak Island		
Patton Cove	1958	15
Total		4,595

Table 11.--Numbers of sea lions observed in Southeastern Alaska, 1957

Location	Visual estimate from airplane
Cape Addington	600
Biorka Island	400
Forrester and Lowrie Islands	2,500
Hazy Island	2,500
Cape Ommaney	350
St. Lazaria	115
Timbered Island	2,250
Total	8,715

Source of data: U.S. Fish and Wildlife Service

The decline in number of animals from the Gulf of Alaska and southward corresponds to the decline on the Kurile Islands on the same latitude (Klumov, 1957) and is probably connected with climatic conditions.

Mathisen (1959) estimated 165,000 Steller sea lions along the North American Pacific Coast. This estimate has been raised to about 175,000 animals by the figures given in this report. Kenyon and Rice (1961) estimated the world population of Steller sea lions to be about 225,000. From all of these figures it is apparent that the center of population density is from the entrance of Cook Inlet to Unalaska. Actual photo counts are given for all the important rookeries in this area.

SUMMARY

1. Predation has been cited as a contributing factor to the decline in runs of salmon in Alaska. Since Steller sea lions and harbor seals are known to eat salmon, they are listed among the predators.

2. A realistic appraisal of damage by sea lions to food fish requires knowledge of the areas and periods of time where these animals feed and an exact estimate of the total population size.

3. Previous methods of estimating marine mammals could not be used because of the many separate populations widely scattered in Alaska.

4. A photographic census technique was developed and is described.

5. The accuracy of the method is discussed for various categories of Steller sea lions.

6. All photographic estimates of the sea lion herds for the years 1956, 1957, and 1958 have been summarized in tabular form. The area covered extends from Cape St. Elias (144° W.) to the Islands of the Four Mountains (170° W.)

7. Diurnal variations were demonstrated, with the highest number of animals seen on the rookeries during daytime.

8. Pronounced seasonal variations were found, with a summer population two to three times as large as the winter one.

9. A limited survey was made of the harbor seals, and about 18,000 animals were photographed during the summer months.

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APPENDIX

NOTES ON DISTRIBUTION AND ABUNDANCE OF HARBOR SEALS *PHOCA VITULINA* IN THE GULF OF ASALKA AND ALEUTIAN ISLANDS AREA

In conjunction with the sea lion surveys an effort was made to count harbor seals *(Phoca vitulina)* whenever they were found.

Favorite hauling grounds of the harbor seals are the long sandy beaches and sandspits, and the islands that are often near the mouths of streams. Frequently harbor seals move only high enough on a sandbar to be out of reach of the surf. This, combined with an extreme wariness to strange sounds such as the noise of an airplane, makes it more difficult to photograph the seals than sea lions. At times some of the seals on larger hauling grounds managed to move out into the water even before the plane flew over them, and when in the water the relatively small seal heads were difficult to spot on a photograph. An example of this movement is shown in a photograph (appendix fig. 1) taken on Trinity Islands on July 24, 1956. A few seals already in the water can barely be spotted. As a rule few seals remained on land during a second flight over a hauling

Appendix figure 1.--One hundred and twenty-three harbor seals on Trinity Islands, July 24, 1956, moving toward water upon arrival of airplane.

ground. Consequently, the counts obtained must always be considered minimum.

Timing of a survey influences the results markedly. For example, during a survey of the Copper River Flats in October 1957, only 30 to 40 seals were seen, whereas several thousand were seen there during the fishing season. This survey may have been an exceptional observation because the presence of large numbers of harbor seals in the fall was established during a seal control program in 1951 (Alaska Fisheries Board and Alaska Department of Fisheries, 1952, p. 44-45).

Since seals are widely scattered and may haul out in small numbers at numerous locations, a complete survey is both a long and arduous task, as well as an expensive one. Furthermore, all that is known about the migrations of the seals is that they may be frequent and extensive.

The results of the surveys are summarized in appendix table 1. The counts given should not be considered as complete survey estimates; they only indicate the number of harbor seals that were seen in the indicated areas at the time of the surveys.

The Trinity Islands south of Kodiak Island accounted for most of the seals during all surveys, although there were seasonal variations in numbers similar to those observed on sea lion rookeries. In both 1956 and 1957, the December survey of the Trinity Islands showed a marked decline in the number of animals from the fall surveys in the same years. A number of reasons may account for the decline. Harbor seals may spread out more along the entire coast during the winter; they may spend a longer time at sea in search of food; or they may migrate to another area during the wintertime.

Although harbor seals are at times found with sea lions, they are usually at the outskirts of the main rookery, as was seen at Chernabura Island in 1958.[1]

The center of population density as revealed by the photographic census lies in the Kodiak Island area. More harbor seals than sea lions were observed in the Chignik district.

[1] See footnote 1 on p. 6.

Appendix table 1.--Numbers of harbor seals (Phoca vitulina), 1956-57, determined from photos

[*Indicates visual estimate]

District, rookery and code number[1]	1956[2]			1957					
	Survey 1, July-Aug.	Survey 2, Sept.	Survey 3, Dec.	Survey 1, March	Survey 2, May	Survey 3, June	Survey 4, Aug.	Survey 7, Sept.-Oct.	Survey 8, Dec.
Prince William Sound-Kenai									
1. Chiswell Islands					1				
6. Point Elrington	15*								
11. Nuka Point	100*								
15. Pye Islands				25				139	
17. Seal Rocks (Prince William Sound)								80	
19. Wooded Island						100			
20. Cape Fairfield	100*								
21. Gravina Bay								29	
22. Schooner Rock[3]									
23. Seal Island			100*					107	
Total	215		100	25	1	100		355	
Kodiak Island									
3. Cape Chiniak								941	
4. Chirikof Island								280	
5. Chowiet Island	15*								
6. Latax Rocks	98					27			
8. Marmot Island	50*			65	30			235	
10. Sea Lion Rock (Marmot Island)						357		4	
11. Cape Sitkinak								15	
12. Twoheaded Island			50*	75				53	
13. Ugak Island	894			2,130		288		2,796	437
15. Perenosa Bay									
16. Seal Island	75*	25*							
17. Trinity Islands	6,533	16,776	3,295	7,800	115	9,468		13,383	418
Total	7,665	16,801	3,345	10,070	145	10,140		17,707	855
Chignik									
3. Cape Kumlik	150*								
8. Sutwik Island	250*								
9. Ugaiushak Island	100*								
10. Chaukliut Island	25*								
11. Kumlik Island	40*								
12. Nakchamik Island	3								
13. Unavikshak Island	15*								
Total	583								
Bristol Bay									
3. Port Heiden (Strogonof Point)	100*								1,295
4. Port Moller									431
Total	100								1,726
Shumagin-Cold Bay									
10. Nagai Island	30*								
12. Sanak Island	45*						5*		
14. Simeonof Island							12		
15. Sushilnoi Rock							478		
17. Unga Cape							35*		
19. Wosnesenski Island						108			
20. Izembek Bay					620		1,142		
21. Kennoy Island							294		
Total	75				620	108	1,966		
Eastern Aleutian Islands									
15. Tigalda Island								8	
17. Ugamak Island								20	
Total								28	

[1]Code numbers from figure 1.

[2]For dates of surveys of rookeries 1 to 19, see tables 1 to 6. Rookeries 20 to 23, which are not shown on tables 1 to 6, were inhabited by harbor seals only. They were surveyed on the dates that coincided with the survey of the closest sea lion rookery.

[3]On August 22, 1957, W. H. Noerenberg observed 50 seals here.

MS #1195

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